A High Prevalence of Diabetes Mellitus and Impaired Glucose Tolerance in the Danagla Community in Northern Sudan

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The prevalence and associated factors of diabetes mellitus (DM) and impaired glucose tolerance (IGT) were studied in a tribal community with an apparently high diabetes prevalence. A sample of 724 subjects aged ≥ 25 years was selected using a multi-stage cluster method and underwent a 75 g oral glucose tolerance test. The crude prevalence of DM and IGT were 8.3 % (men 9.9 %; women 7.5 %) and 7.9 % (men 4.1 %; women 9.7 %), respectively. Age-adjusted prevalence rates, according to the standard population of Segi, were 10.4 % (95 % CI 7.7–13.2) and 9.8 % (95% CI 7.2–12.5) for DM and IGT, respectively. No urban/rural differences were found in the prevalence rates of DM and IGT. New cases (5.1%) were almost twice as common as previously known cases (3.2 %). Family history of diabetes, obesity, and advanced age were associated with higher rates of diabetes. The results confirmed that diabetes is common in the Danagla community compared to other communities of northern Sudan. Varying environmental, nutritional, and genetic factors may contribute to this high prevalence. These findings will have profound impact on the health services for this community and the Sudan as a whole.

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Introduction

The reported prevalence of diabetes mellitus varies widely between countries, between different ethnic groups in the same country, and between different age groups within the same population.[1,2] Information on the prevalence of diabetes mellitus (DM) in Africa is sparse. Only a few studies have used the WHO criteria for the formal diagnosis of diabetes.[3,4]

Recently we have conducted a population-based study of the prevalence of diabetes mellitus (DM) and impaired glucose tolerance (IGT) among the adult population in the northern parts of the Sudan.[5] The results showed a wide difference in diabetes prevalence in the three regions studied, with rates ranging from 0.9 % to 5.5 %.

A general impression among practising clinicians is that a certain tribal community, the Danagla community, in the Northern State of Sudan, has a particularly high prevalence of diabetes. The purpose of the present investigation was to study the epidemiology of glucose intolerance in this community and to compare the results with those previously found in the other parts of Sudan.

Study Design and Methods

Study Design

In 1992–93, the Sudan was divided into six northern and three southern states. The northern states are Khartoum State, Darfor State, Kordofan State, Central State, Eastern State, and Northern State. This study was conducted in the Northern State (1.3 million inhabitants). The Danagla tribe is one of five tribes in the Northern State that lives by the River Nile, engaged mainly in subsistence farming. Egyptian migrants came long ago to the Danagla areas, where they settled, mixed and intermarried with the local community, acquiring Sudanese citizenship as part of the Danagla group. With time this immigrant group have introduced into the area their own traditions and way of living, particularly trading and sweet-making, changing the lifestyle of the indigenous people.

The selection of the locations and populations was conducted by multi-stage cluster sampling, as previously described.[5,6] In brief, a three-stage design was used

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separately for urban and rural areas. The first and second stage units were selected with probability proportional to the size of the populations. The first stage unit consisted of primary sampling units—the Village Councils in rural areas and the Quarter (Town) Councils in urban areas. In the second stage, a village was selected from each Village Council and a segment from each Quarter Council. The third stage unit was the households, which were selected from each village or segment using systematic sampling with probability inversely proportional to the overall selection probability of the second stage units. In the Northern State, four clusters inhabited by Danagla community people were selected from two urban Quarter Councils (Dongola and Argo) and two rural Village Councils (Muragha and Abti-East). The people of Argo and Abti-East are of Egyptian descent.

In each cluster, a house-to-house survey was conducted through a transect of the whole local community. A total of 40 households were selected to achieve a minimum of 100 subjects in each of the four clusters. In each household all members ≥ 25 years of age were invited to participate, and after informed consent had been obtained, all the members who were eligible and present at the time of the study agreed to take part.

Methods

After approval by the local authorities, 724 subjects, aged ≥ 25 years, were interviewed and examined. This number included all those who were invited to participate; however, the number of eligible subjects who were not present at the time of the interview was not documented. A simple questionnaire including socio-demographic indicators was completed, and the presence of known diabetes, its treatment, and family history of diabetes was recorded. Weight (kg), while wearing indoor clothing, and height (m), without shoes, were measured and body mass index (BMI, kg m^{-2}) calculated. Obesity was defined as ≥ 25 kg m^{-2} for females and ≥ 27 kg m^{-2} for males,[7,8] and BMI < 20 kg m^{-2} was considered underweight. Known diabetes was documented when subjects reported to have been treated for diabetes with diet, oral agents, and/or insulin. All subjects with known DM had their random blood glucose measured. Subjects who were not known to have diabetes received an oral glucose load (75 g of anhydrous glucose) and a capillary blood sample was taken 2 h ($\pm$ 5 min) later. Capillary blood glucose was measured using a reflectance photometer (Reflolux II®, Boehringer-Mannheim, Germany).[9,10] For quality control, a venous whole blood sample was drawn consecutively from every 10th subject into fluoride oxalate tubes, centrifuged, and the plasma separated and stored frozen to be analysed in the central laboratory of Soba University Hospital, Khartoum, by a glucose oxidase method (Beckman Instruments Inc., Palo Alto, CA, USA). Excellent correlation ($r = 0.99$) with the method used in the field was obtained in the 72 subjects with double glucose determination. The mean ($\pm$ SD) of the difference between plasma and capillary glucose was 0.9 ± 0.6 mmol l^{-1}.

Diabetes mellitus or impaired glucose tolerance (IGT) was diagnosed according to WHO revised criteria,[11] i.e. a glucose value of ≥ 11.1 mmol l^{-1} for DM and a value 7.8–11.0 mmol l^{-1} for IGT. Within the age range of 30–64 years, the age-specific prevalence rates of diabetes were calculated in 5-year intervals and standardization was performed using the direct method[12] against the standard world population of Segi.[13]

Statistical Analysis

Data are given as mean $\pm$ SD, and as medians for skewed distributions. Data were analysed using a Macintosh computer (JMP 3.1, Statistical software for the Macintosh, SAS Institute Inc., Cary, NC, USA). Group means were compared by unpaired *t*-test; χ^2 and CIs were calculated where appropriate. Multiple logistic regression analysis was conducted to test the most important variables suggestive of diabetes risk, using the statistical programme package SAS for Windows, version 6.08 (SAS Institute Inc., Cary, NC, USA). Odds ratios (OR) for continuous variables given in Table 5 were standardized for standard deviations (SDs), i.e. the OR shows the relative change in the odds of the event becoming a case when the predictor variable increases by 1 SD. For dichotomous variables the OR shows the relative change in the odds when the variable changes from 0 to 1. A p value of < 0.05 was considered statistically significant.

Results

Age and Sex

Table 1 shows some clinical characteristics of the population. In this population (urban 461, rural 263 subjects), 61 % were aged ≤ 44 years, 30 % in the age group 45–64 years, and 9 % were aged ≥ 65 years. Sixty-seven per cent were females (f:m, 2:1). The high female:male ratio is due to the fact that men were less often at home at the time of study. Regular migration to big cities or even abroad contributed to this unavoidable selection bias in this population.

Prevalence of Diabetes Mellitus and IGT

The crude prevalences of DM and IGT (Table 2) were not significantly different between urban and rural populations. The prevalence of new cases of DM was almost twice that of known cases (5.11 % vs 3.18 %). The mean random blood glucose concentration for the 23 previously diagnosed diabetic subjects was 15.9 ± 5.8 mmol l^{-1}. Of these 23 patients, 16 (69.6 %) were taking oral hypoglycaemic agents, 6 were treated with insulin, and only 1 patient was on diet alone. None of the newly discovered diabetic subjects complained of hyperglycaemic symptoms.

Table 1. Some characteristics of the Danagla community, northern Sudan

	Urban			Rural			Total
	Men	Women	Total	Men	Women	Total	
Number	172	289	461	70	193	263	724
Age (yr) Median (range)	39 (25–80)	38 (25–80)	38 (25–80)	38.5 (25–85)	40 (25–80)	39 (25–85)	39 (25–85)
BMI (kg m^{-2}) (mean ± SD)	24.9 ± 5.0	26.5 ± 5.9	25.9 ± 5.6	21.7 ± 2.9	23.4 ± 4.7	22.9 ± 4.3	24.8 ± 5.4
2-h glucose after 75g OGTT (mmol l^{-1})[a] (mean ± SD)	6.3 ± 3.0	6.8 ± 3.2	6.6 ± 3.1	6.7 ± 4.30	6.3 ± 2.0	6.4 ± 2.8	6.5 ± 3.0

[a]Known diabetic subjects ($n = 23$) were excluded.

Table 2. Prevalence of diabetes mellitus (DM) and impaired glucose tolerance (IGT) in the Danagla community, northern Sudan

	Urban	Rural	Total
Total number studied	461	263	724
Males	172	70	242
Females	289	193	482
Number of diabetic subjects	44	16	60
Known cases	15	8	23
New cases	29	8	37
Number of IGT subjects	37	20	57
Prevalence of DM	9.54 (6.9–12.2)	6.08 (3.2–9.0)	8.28 (6.3–10.3)
Known cases	3.25 (1.6–4.9)	3.04 (1.0–5.1)	3.18 (1.9–4.5)
New cases	6.29 (4.1–8.5)	3.04 (1.0–5.1)	5.11 (3.5–6.7)
Prevalence of IGT	8.03 (5.5–10.5)	7.60 (4.4–10.8)	7.87 (5.8–9.9)
Prevalence of total glucose intolerance (TGI)	17.6 (14.1–21.1)	13.7 (9.5–17.8)	16.2 (13.5–18.9)

Figures denote number of subjects or percentage of the populations (95% CI).

Dividing the data by the four locations studied, the prevalence rates for diabetes and IGT were as follows: Dongola 8.0 % and 6.3 %; Muraga 5.3 % and 7.3 %. Argo 12.0 % and 10.7 %; Abti-East 7.1 % and 8.0 %.

Age- and sex-specific prevalence rates of DM and IGT are presented in Table 3. Prevalence of diabetes increased with age in both men and women ($p < 0.05$ and $p < 0.005$, respectively), and in the urban and rural populations ($p < 0.001$ and $p < 0.05$, respectively). Higher rates of total glucose intolerance (DM+IGT) were attained at an earlier age, although not significantly so, in the urban compared with the rural population. The age- and sex-standardized (Segi) prevalence rates are presented in Table 4. Prevalence was 10.4 % (95 % CI; 7.7–13.2) for DM and 9.8 % (95 % CI; 7.2–12.5) for IGT.

Family history of diabetes in first degree relatives was reported by 36 % of the study population (73 % of the diabetic, and 30 % of non-diabetic subjects). The frequency of family history was similar in the urban and rural populations (36.9 % vs 34.6 %). The frequency of

Table 3. Age- and sex-specific prevalence rates of diabetes mellitus and impaired glucose tolerance (IGT) in the Danagla community, northern Sudan

Age groups (yr)	Number			Diabetes			IGT			Total glucose intolerance		
	Men	Women	Total	Men	Women	Total	Men	Women	Total	Men	Women	Total
25–44	145	297	442	6.9	5.0	5.7	4.1	7.7	6.6	11.0	12.8	12.2
45–64	64	150	214	15.6	12.0	13.1	6.2	12.0	10.3	21.9	24.0	23.4
≥ 65	33	35	68	12.1	8.6	10.3	–	17.1	8.8	12.1	25.7	19.1
All ages	242	482	724	9.9	7.5	8.3	4.1	9.7	7.9	14.0	17.2	16.2

Figures denote numbr of subjects or percentage of the populations.

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Table 4. Age- and sex-standardized[a] prevalence of diabetes and impaired glucose tolerance (IGT) in the Danagla community, northern Sudan

	n	Diabetes	IGT	Total glucose intolerance
Urban	315	12.1 (8.5–15.7)	10.5 (7.1–13.9)	22.5 (17.9–27.1)
Men	118	15.8 (9.2–22.4)	4.5 (0.8–8.2)	20.2 (13.0–27.4)
Women	197	10.7 (6.4–15.0)	13.5 (8.7–18.3)	24.2 (12.1–36.4)
Rural	169	7.5 (3.5–11.5)	9.3 (4.9–13.7)	16.8 (11.2–22.4)
Men	43	2.8 (2.1–7.7)	4.4 (1.7–10.5)	7.2 (0.5–14.9)
Women	126	8.3 (3.5–13.1)	10.2 (4.9–15.5)	18.5 (11.7–25.3)
Total	484	10.4 (7.7–13.1)	9.8 (7.1–12.4)	20.3 (16.7–23.9)

Figures denote number of subjects or percentage of the populations (95 % CI). [a]Five-year age- and sex-specific rates (30–64 year) were calculated, and standardization was performed with the direct method against the standard world population of Segi.

family history was similar among subjects who were obese (39 %), of normal BMI (34 %) or underweight (34 %).

The overall prevalence of obesity was 38 % (women 45 %; men 24 %). The mean BMI was significantly lower in males than females (24.0 ± 4.7 vs 25.3 ± 5.7 kg m^{-2}; $p < 0.005$). BMI was greater in the urban population compared with the rural (25.9 ± 5.6 vs 22.9 ± 4.3; $p < 0.0001$). In logistic regression, age, BMI, and family history turned out to be the most important predictors for diabetes mellitus in this community (Table 5).

The proportion of obese subjects increased significantly with age, reaching 50.4 % in the age group 45–54 years, and declined thereafter. The crude prevalence of diabetes and IGT among the non-obese subjects (4.6 % and 5.8 %, respectively) was much lower than among the obese subjects (14.9 % and 11.6 %, respectively, $p < 0.0001$). In all locations studied, the prevalence of obesity was higher in Dongola (46.5 %) and Argo (46.3 %) than in Muraga (23.2 %) and Abti-East (24.1 %), providing a trend of increasing prevalence of obesity from rural (23.6 %) to urban (46.4 %) settlement.

Discussion

This study has substantiated reports from local physicians that certain tribal communities in northern Sudan have a high prevalence of diabetes mellitus. The overall crude prevalence rate of 8.3 % found in the Danagla community is much higher than that found previously by our group.[5] A higher prevalence rate (10 %) of diabetes and IGT in the group with the Egyptian background suggests a role for the genetic admixture in this group. Environmental factors, such as reduced physical activity, increased BMI and obesity, and increased energy intake, may also have played an important role for the high diabetes prevalence in these communities. Recent studies from Egypt have shown that the prevalence of diabetes ranges from 2.6 % in agricultural rural populations to 9.2 % in urban populations,[14] and, in another report, the rural prevalence has increased to 4.9 % and the urban to 20 % with higher socio-economic status.[15] A stepwise increase in risk factors for diabetes, such as sedentary life, increased obesity, and urbanization, was noted in these Egyptian populations.[15] These features of the Egyptian population are similar to our population as our urban population had significantly higher BMI, and were more obese than the rural. With this in mind, an increasing prevalence of diabetes and IGT would be expected with more urbanization and modernization of life-style in our population.

Table 5. Odds ratio and CIs of various parameters for diabetes

Variable	OR (95% CI)	*p*-value
Sex (f = 1; m = 0)	0.78 (0.45–1.35)	0.3747
Rural/urban (Rural = 1/urban = 0)	1.64 (0.91–2.98)	0.1022
Family history (yes = 1; no = 0)	6.37 (3.50–11.6)	0.0001
Age[a]	1.55 (1.21–1.97)	0.0005
Body mass index[a]	1.89 (1.48–2.40)	0.0001

For sex, urban/rural, and family history the OR shows the relative change in the odds when the variable changes from 0 to 1.
[a]ORs standardized to 1 SD increase.

The overall prevalence of obesity (38 %) was higher compared with 24.4 % found in the previous population-based study in Sudan.[5] This difference may reflect the different life-style and other nutritional habits of our present population. Equally, however, among the obese subjects in this study, 14.6 % had diabetes compared with 7.7 % in that study and family history of diabetes among the diabetic subjects was more common (73.3 % vs 64 %). In the earlier report from Sudan, we observed that diabetes prevalence in other populations in the Northern State (5.5%) was higher than in the Central State (4 %), or in Kordofan State (0.9 %) in the western, desert-like, parts of the country. The different prevalence of risk factors for diabetes, genetic and environmental, in these populations may explain the wide differences. Moreover, the fact that the diabetes prevalence in the Northern State in general is lower than that of the Danagla community, despite the same environment and similar living conditions, suggests that the latter community represents a diabetes-susceptible group,

characterized by excess prevalence of obesity. Changes in life-style, such as reduced physical activity and different eating habits, common in the Egyptian sub-group may have contributed to the excess diabetes prevalence.

As found in most populations,[16–18] the prevalence of diabetes increased steadily with age, both in males and females. The rate at which diabetes increases with age was much less in rural populations than in the urban ones. This is probably partly explained by the deterioration of glucose tolerance among urban settlers exposed to obesity and less physical activity. Alternatively, the excess in diabetes prevalence in the elderly rural subjects may reflect a shorter life expectancy among the urban diabetic subjects.

Recently, a WHO Ad Hoc Diabetes Reporting Group reported great variation in the prevalence of diabetes mellitus[19] when global comparison was made after age-standardization according to the population of Segi. The age-standardized prevalence rate of diabetes in our study is higher than in Vietnam (Hanoi),[20] Sri-Lanka,[21] and Malaysian Malays.[22] In the Pacific region, although much higher rates were found, our figures are higher than those in some rural and suburban communities.[19,23] Among the American populations, our figures are higher than in the Mapuche Indians of Chile and similar to some US non-Hispanic black populations.[19] In comparison with the European countries, the prevalence of diabetes in this study is higher than in Polish and Russian populations and comparable to some Italian and Maltese populations.[19]

A high prevalence of total glucose intolerance (16.2 %) is a major concern for diabetes care delivery in this community in particular and for Sudan in general. Longitudinal studies indicate that almost one-third of the IGT subjects progress to Type 2 diabetes, and further implicate excess risk of the related long-term vascular complications.[24,25]

In summary, we have shown that the Danagla community of Northern Sudan has a particularly high prevalence of diabetes mellitus and impaired glucose tolerance. Positive family history, obesity, and age were all significant risk factors for the development of diabetes in this community.

With an increase in risk factors for diabetes and a high prevalence of IGT, a substantial increase in the prevalence of diabetes is expected, indicating the high cost and burden that glucose intolerance may represent to the health care services in Sudan. Increased public awareness of the hazards of important modifiable risk factors related to life-style should reduce the prevalence of glucose intolerance in this population.

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